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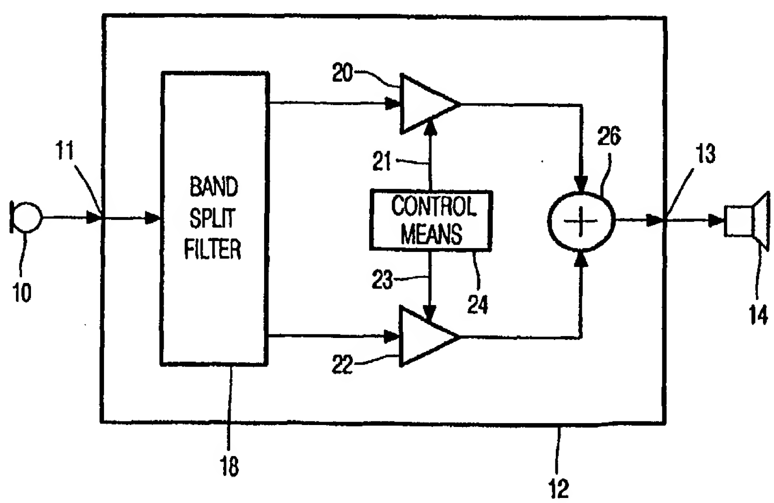


(57) Abstract

The hearing instrument comprises a circuit (12) for transforming an audio signal (11) into an output signal (13), which circuit (12) comprises filter means (18) for dividing the audio signal (11) into at least two frequency band signals and amplifier means (20, 22) for amplifying the frequency band signals. The circuit (12) further comprises control means (24) for the generation of at least first (21) and second (23) control signals which control the amplification of the frequency band signals and means (26) for including the amplified frequency band signals into the output signal (13). The control means (24) are embodied so as to increase a level of the first control signal (21) while simultaneously decreasing the level of the second control signal (23), or vice versa. The control means (24) may comprise a single control element (38), e.g. a variable resistor. In this way, the hearing instrument can easily be configured as a BILL or as a TILL or as a substantially linear hearing instrument.

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Hearing instrument

The invention relates to a hearing instrument comprising a circuit for transforming an audio signal into an output signal, which circuit comprises filter means for dividing the audio signal into at least two frequency band signals and amplifier means for amplifying the frequency band signals, whereby the circuit further comprises control means for the generation of at least first and second control signals which control the amplification of the frequency band signals and means for including the amplified frequency band signals into the output signal.

The invention further relates to a circuit for transforming an audio signal into an output signal.

A hearing instrument according to the preamble is known from Gennum Corporation's "GS3027/GS3028 Preliminary data sheet", April 1997. Hearing instruments often comprise AGC-units. These AGC-units are used to amplify received signals in order to achieve an improved perception of those signals by a hearing-impaired user of the hearing instrument. In general, the amplification of the AGC-units depends on the frequency and the amplitude of the received signals. For instance, for people who are not able to hear high frequency components very well, the AGC-units can be configured in such a way that low frequency components of the received signals above a certain amplitude are compressed, which leads to an improved perception of the high frequency components. A hearing instrument in which this concept is implemented is often referred to as a TILL hearing instrument, i.e. a Treble Increase at Low signal Levels hearing instrument. Otherwise, for people who are not able to hear low frequency components very well, the AGC-units can be configured in such a way that high frequency components of the received signals above a certain amplitude are compressed, which leads to an improved perception of the low frequency components. A hearing instrument in which this concept is implemented is often referred to as a BILL hearing instrument, i.e. a Bass Increase at Low signal Levels hearing instrument.

The known hearing instrument can be configured as a BILL or as a TILL hearing instrument. The hearing instrument comprises thereto a band split filter by means of which a received audio signal is divided into a low frequency band and a high frequency band signal. Thereupon, these frequency band signals are amplified in two AGC-units, one for each frequency band signal. The hearing instrument further comprises two variable resistors, one for each AGC-unit, for the purpose of controlling the compression ratios of the AGC-units. The compression ratio corresponds to the ratio between, on the one hand, an increase in amplitude of an input signal of the AGC-unit which must be amplified and, on the other hand, the increase in amplitude of the corresponding output signal resulting from the AGC-unit.

An object of the invention is to provide another hearing instrument, which can be conveniently configured as a BILL or as a TILL hearing instrument. This object is achieved in the hearing instrument according to the invention, which is characterized in that the control means are embodied so as to increase a level of the first control signal while simultaneously decreasing the level of the second control signal, or vice versa. By this measure, the compression ratios of both AGC-units can be controlled simultaneously by the control means. Starting from a 'neutral position' in which the levels of the control signals are substantially equal to each other and in which the compression ratios of both the AGC-units are also substantially equal to each other and in which the hearing instrument exhibits a substantially linear behaviour, a TILL hearing instrument can be obtained by increasing the level of the first control signal, which controls the low frequency AGC-unit, while decreasing the level of the second control signal, which controls the high frequency AGC-unit. As a consequence, the compression ratio of the first AGC-unit is increased, e.g. to 3:1, while the compression ratio of the second AGC-unit is decreased to about 1:1. In the same way, a BILL hearing instrument can be obtained from the 'neutral position' by decreasing the level of the first control signal while increasing the level of the second control signal. Then the compression ratio of the first AGC-unit is decreased to about 1:1, while increasing the compression ratio of the second AGC-unit to, for example, 3:1.

An embodiment of the hearing instrument according to the invention is characterized in that the control means comprise a single control element. By using only a single control element a relatively simple, cheap and small hearing instrument is obtained.

The above object and features of the present invention will be more apparent from the following description of the preferred embodiments with reference to the drawings, wherein:

Figure 1 shows a block diagram of a hearing instrument according to the invention,

Figure 2 shows a preferred embodiment of the hearing instrument according to the invention.

Figure 3 shows the relation between, on the one hand side, the compression ratio of the two AGC-units included in the hearing instrument shown in Figure 2 and, on the other side, the rotation of the potentiometer which is also included in the hearing instrument shown in Figure 2.

In the Figures, identical parts are provided with the same reference numbers.

Figure 1 shows a block diagram of a hearing instrument according to the invention. Such a hearing instrument can be used to improve the perception of sounds by a hearing-impaired user. The hearing instrument comprises a microphone 10 for converting a received sound signal into an electric audio signal 11. This audio signal 11 is transformed in a circuit 12 into an electric output signal 13, which is subsequently converted to sound by an electro-acoustic converter 14. In the circuit 12 the audio signal 11 is first divided by a band split filter 18 into a low frequency band signal and a high frequency band signal. These frequency band signals are amplified by the controllable amplifiers, e.g. AGC-units, 20 and 22, which are controlled via control signals 21 and 23 by the control means 24. The control means can increase the level of the control signal 21 while simultaneously decreasing the level of the control signal 23, and vice versa. Adder 26 adds the amplified frequency band signals together

and supplies the resulting electric output signal 13, possibly via an extra amplifier, to the electro-acoustic converter 14.

Figure 2 shows a preferred embodiment of the hearing instrument according to the invention. The hearing instrument comprises a microphone 10 for converting a received sound signal into an electric audio signal 11. This audio signal 11 is transformed in a circuit 12 into an electric output signal 13, which is subsequently converted to sound by an electro-acoustic converter 14. The circuit 12 includes an integrated circuit 32, i.e. the GS3027 known from the before mentioned data sheet. This integrated circuit 32 includes a band split filter and, coupled thereto, a high and a low frequency AGC-unit. The audio signal 11 is supplied to an input 30 of the integrated circuit 32, i.e. pin 7 of the GS3027. The band split filter divides the audio signal 11 into a low frequency band signal and a high frequency band signal. These frequency band signals are amplified by the AGC-units. The compression ratios of these AGC-units can be controlled between 1:1 and 4:1 via control signals 21 and 23 by means of externally applied resistors 36, 38, 40 and 42, which form the control means 24. In the integrated circuit 32 the amplified frequency band signals are added together and the resulting electric output signal 13, which is present at an output 34 (i.e. pin 14 of the GS3027), is supplied to the electro-acoustic converter 14.

The resistor 38 is a variable resistor, e.g. a linear or logarithmic potentiometer. A first contact of this potentiometer 38 is coupled via the resistor 36 to a first reference voltage 1:1 (i.e. pin 13 of the GS3027). A second contact of the potentiometer 38 is coupled via the resistor 40 to the first reference voltage 1:1. A wiper contact of the potentiometer 38 is coupled via the resistor 42 to a second reference voltage 4:1 (i.e. pin 10 of the GS3027). At the first contact of the potentiometer 38 the first control signal 21 is present, which is supplied to the GS3027 via pin 12. At the second contact of the potentiometer 38 the second control signal 23 is present, which is supplied to the GS3027 via pin 11. The control signals 21 and 23 comprise voltages which control the compression ratios of the voltage controlled AGC-units in the GS3027. The voltage 21, and thus the compression ratio of the low frequency AGC-unit, depends on the ratio between, on the one hand, the resistance $R_{LO1}$ between the first contact of the potentiometer 38 and the first reference voltage 1:1 and, on the other hand, the resistance $R_{LO2}$ between the first contact and the second reference voltage 4:1. In this example, $R_{LO1}$ is fixed and equal to the resistance of the resistor 36 and $R_{LO2}$ is variable and equal to the sum of the resistance of the resistor 42 and of the resistance of the potentiometer 38 between the wiper contact and the first contact. If the wiper contact of the potentiometer 38 is rotated in negative

direction, $R_{LO2}$ decreases which results in a decrease of the voltage 21. If the wiper contact of the potentiometer 38 is rotated in positive direction, $R_{LO2}$ increases which results in an increase of the voltage 21.

The voltage 23, and thus the compression ratio of the high frequency AGC-unit, depends on the ratio between, on the one hand, the resistance $R_{HI1}$ between the second contact of the potentiometer 38 and the first reference voltage 1:1 and, on the other hand, the resistance $R_{HI2}$ between the second contact and the second reference voltage 4:1. In this example, $R_{HI1}$ is fixed and equal to the resistance of the resistor 40 and $R_{HI2}$ is variable and equal to the sum of the resistance of the resistor 42 and of the resistance of the potentiometer 38 between the wiper contact and the second contact. If the wiper contact of the potentiometer 38 is rotated in negative direction, $R_{HI2}$ increases which results in an increase of the voltage 23. If the wiper contact of the potentiometer 38 is rotated in positive direction, $R_{HI2}$ decreases which results in a decrease of the voltage 23.

In this example, the following component values can be used to obtain the curves as shown in Figure 3: the resistance of the resistors 36 and 40 is equal to 20 kΩ, the resistance of the resistor 42 is equal to 2 kΩ and the resistance of the potentiometer 38 is equal to 200 kΩ.

Figure 3 shows by means of two curves 50 and 52 the relation between, on the one hand side, the compression ratio of the two AGC-units included in the hearing instrument shown in Figure 2 and, on the other side, the rotation of the potentiometer 38 which is also included in the hearing instrument shown in Figure 2. In this Figure, the rotation of the potentiometer 38 (in degrees) is plotted on the horizontal axis, and the compression ratio of the AGC-units is plotted on the vertical axis. The curve 50 shows how the compression ratio of the low frequency AGC-unit depends on the rotation of the potentiometer 38. The curve 52 shows how the compression ratio of the high frequency AGC-unit depends on the rotation of the potentiometer 38. When the rotation of the potentiometer 38 is at 0 degrees, the control means 24 is in its 'neutral position', i.e. the levels of the control signals 21 and 23 are equal to each other and the compression ratios of both the AGC-units are equal to about 1.4:1. Starting from this 'neutral position', in which the hearing instrument exhibits a substantially linear behaviour, a TILL hearing instrument can be obtained by a negative rotation of the potentiometer 38. For instance, when the rotation of the potentiometer 38 is equal to -135 degrees the compression ratio of the low frequency AGC-unit is equal to 3:1, while the compression ratio

of the high frequency AGC-unit is equal to 1.1:1, i.e. the high frequency AGC-unit amplifies the high frequency band signal substantially linear without compression.

It is also possible to obtain a BILL hearing instrument by a positive rotation of the potentiometer 38. For instance, when the rotation of the potentiometer 38 is equal to 135 degrees the compression ratio of the high frequency AGC-unit is equal to 3:1, while the compression ratio of the low frequency AGC-unit is equal to 1.1:1, i.e. the low frequency AGC-unit amplifies the low frequency band signal substantially linear without compression.

CLAIMS

1. A hearing instrument comprising a circuit (12) for transforming an audio signal (11) into an output signal (13), which circuit (12) comprises filter means (18) for dividing the audio signal (11) into at least two frequency band signals and amplifier means (20,22) for amplifying the frequency band signals, whereby the circuit (12) further comprises control means (24) for the generation of at least first (21) and second (23) control signals which control the amplification of the frequency band signals and means (26) for including the amplified frequency band signals into the output signal (13), characterized in that the control means (24) are embodied so as to increase a level of the first control signal (21) while simultaneously decreasing the level of the second control signal (23), or vice versa.

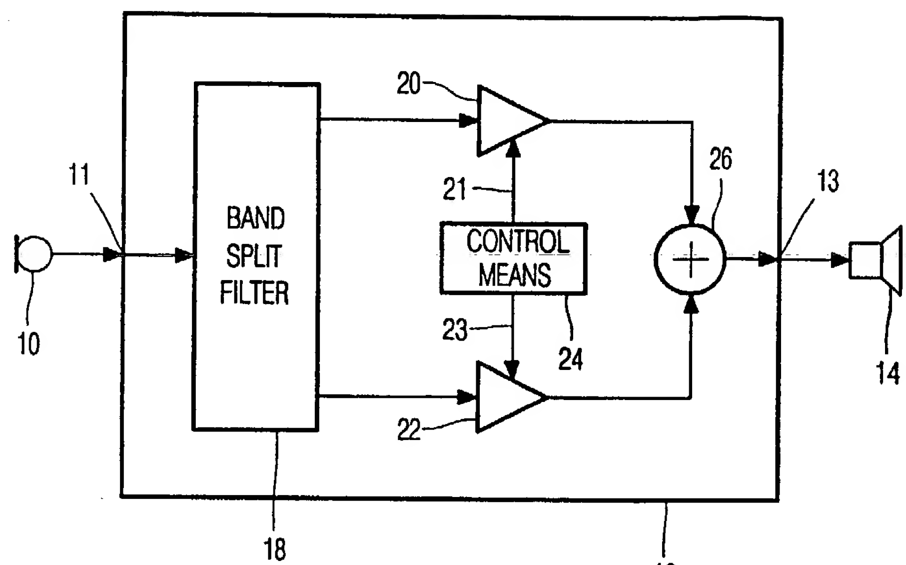
2. A hearing instrument according to Claim 1, characterized in that the control means (24) comprise a single control element (38).

3. A hearing instrument according to Claim 1 or 2, characterized in that the control element (38) comprises a variable resistor (38), whereby first and second contacts of the variable resistor (38) are coupled via, respectively, first (36) and second (40) resistors to a first reference voltage (1:1), and whereby a wiper contact of the variable resistor (38) is coupled to a second reference voltage (4:1), whereby the first (21) and second (23) control signals comprise voltages which are present at, respectively, the first and second contacts of the variable resistor (38), and whereby the amplifier means (20,22) comprise voltage controlled amplifiers.

4. A circuit (12) for transforming an audio signal (11) into an output signal (13), which circuit (12) comprises filter means (18) for dividing the audio signal (11) into at least two frequency band signals and amplifier means (20,22) for amplifying the frequency band signals, whereby the circuit (12) further comprises control means (24) for the generation of at least first (21) and second (23) control signals which control the amplification of the frequency band signals and means (26) for including the amplified frequency band signals into the output signal (13), characterized in that the control means (24) are embodied so as to increase a level of the first control signal (21) while simultaneously decreasing the level of the second control signal (23), or vice versa.

5. A circuit according to Claim 4, characterized in that the control means (24) comprise a single control element (38).

6. A circuit according to Claim 4 or 5, characterized in that the control element (38) comprises a variable resistor (38), whereby first and second contacts of the variable resistor (38) are coupled via, respectively, first (26) and second (30) resistors to a first reference voltage (1:1), and whereby a wiper contact of the variable resistor (38) is coupled to a second reference voltage (4:1), whereby the first (21) and second (23) control signals comprise voltages which are present at, respectively, the first and second contacts of the variable resistor (38), and whereby the amplifier means (20,22) comprise voltage controlled amplifiers.


BAND
SPLIT
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CONTROL
MEANS
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FIG. 1

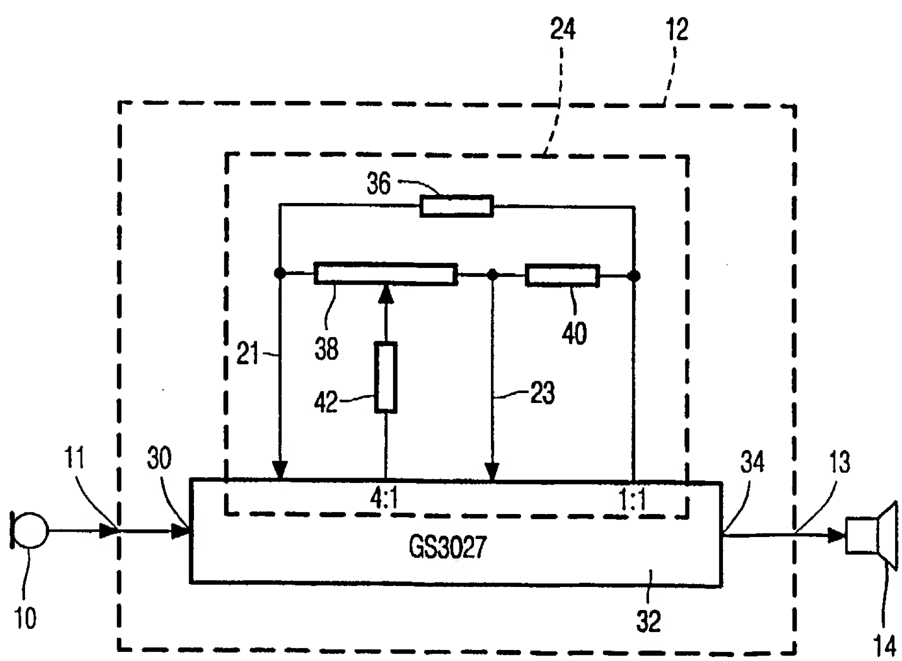
24
12
36
38
40
21
23
42
11
30
34
13
4:1
1:1
GS3027
10
32
14

FIG. 2

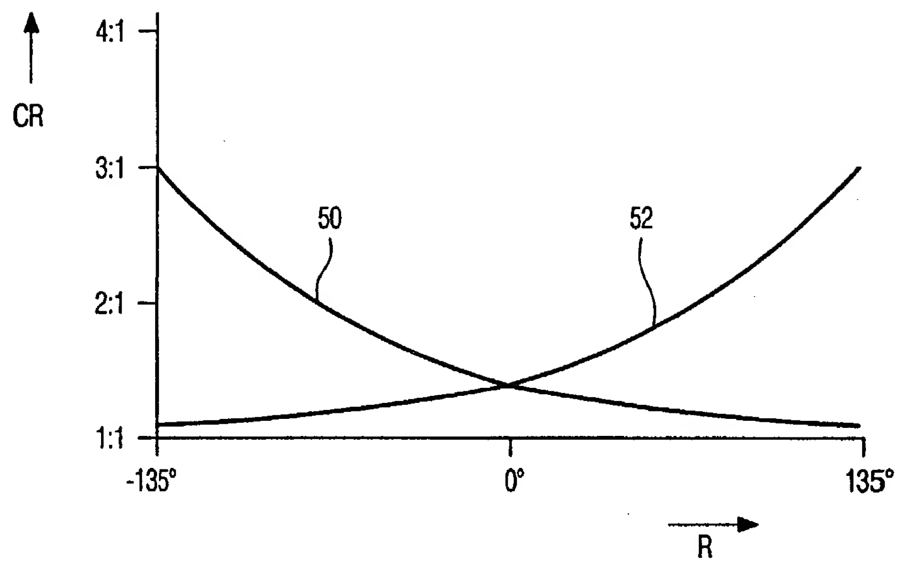


FIG. 3

# INTERNATIONAL SEARCH REPORT

International application No.
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## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04R 25/00 // H03G 5/10

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H03G, H04R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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EPODOC

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| Y | GS3027/GS3028-DATASHEET from GENNUM CORPORATION P.O. Box 489, Stn. A, Burlington, Ontario, Canada Document No. 521 - 34 - 03, Resistors $R_H$ and $R_L$ and accompanying text. -- | 1,2,4,5 |
| Y | QUAD brochure from Quad Electroacoustics Ltd, Huntingdon, Cambs.; PE18 7DB England Tilt control of QUAD preamplifiers Model 34 and Model 44 -- | 1,2,4,5 |

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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| | | SE 0354955 T3 | |
| | | FI 895949 D | 00/00/00 |
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